Transmission-Based Electrical Servo Actuators [TBA's]

DE-AC26-01NT41309
Phase I, 18 months, $425,611
Optional Phase II, 24 months, $450,386

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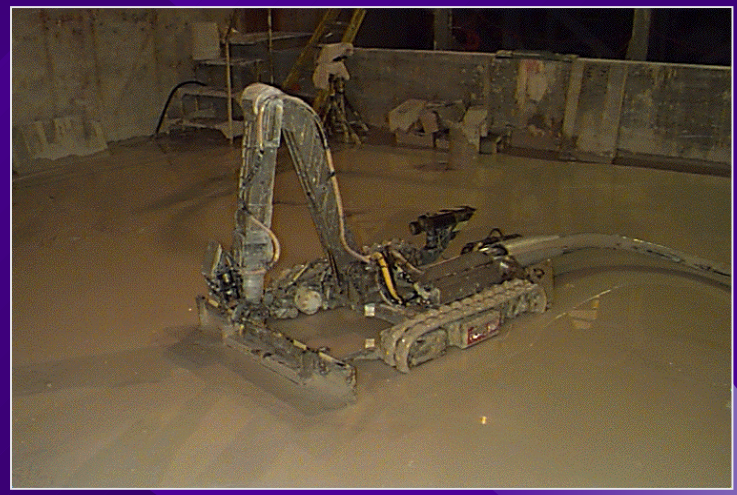
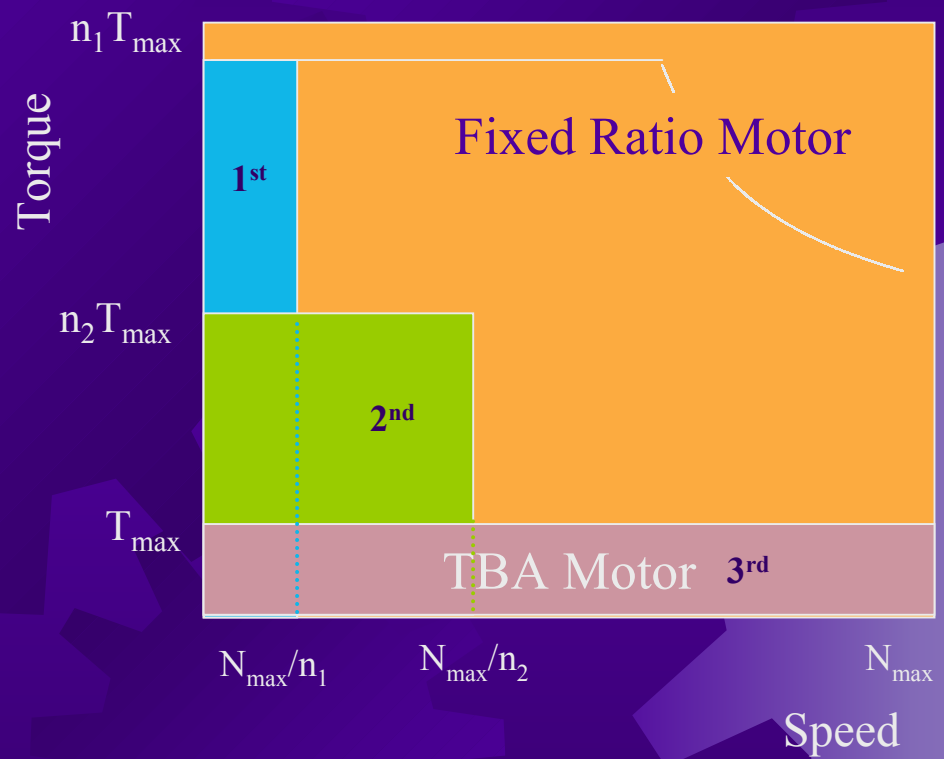
Relevancy & Technical Approach – Background

- High rad/hazards EM projects > robotics & remote handling systems.
- 100 kg " D&D payloads " tons.
- High payloads, long reach systems > electro hydraulic manipulators…power/torque density.
  - Higher complexity, lower reliability, lower maintainability > much greater LC costs.
  - Industrial trend toward electrical drives.
- TBA concept will allow electrical drives to operate in the range of hydraulic drives.



What is a TBA?

- Conventional electrical servoactuators
  - Fixed gear reduction
  - Moderate speed/high power DC or AC motors
- Transmission-based electrical servoactuators
  - Variable gear reduction
  - Trade motor mass for transmission mass
  - High-speed/high power DC or AC motors



Relevancy & Technical Approach – Goals

- **Overall**: **Explore the practicality** of using multi-speed transmissions to extend the operating range of electrical servo actuators for EM applications, ultimately reducing life cycle costs of remote systems.
- **Sub Goals [Phase I] for TBA's: Evaluate Feasibility**
  - The feasibility of multi-speed transmission mechanical miniaturization.
  - The feasibility of high performance servo control with transmission gear ratio changing.
  - The feasibility of approaching the power and torque density of electro hydraulic actuators with TBA-based electrical drives.

Relevancy & Technical Approach – Goals

- **Sub Goals for Phase II: Commercial Viability**
  - Design & fabricate pre-production prototype actuator.
  - Evaluate prototype performance in a high-believability test setting.
  - Establish technology transfer strategy for commercialization.

Relevancy & Technical Approach – Technical Approach & Scope

- Phase I – Evaluate TBA ***concept feasibility***
  - Conceptual design of both discrete and continuously variable transmission (DVT and CVT) configurations
  - Dynamic simulation and analysis of concepts - control
  - Develop servo control concepts
  - Fabricate functional demonstrator
  - Proof-of-principle experiments
- Phase II - Evaluate ***commercial viability***
  - Design and fabricate pre-production prototype
  - Experimental evaluation performance
    - Bench level
    - D&D system level - integrate with a real system
  - Project manufacturing/production factors

Relevancy & Technical Approach – Maturity & EM Relevance

- Technology Maturity
  - Project was a response to the NETL Applied Research PRDA for D&D.
  - DVT, CVT technologies base in vehicles.
  - Mechanical miniaturization in consumer electronics, etc.
  - Nonlinear and hybrid control theories.
  - Phase I: Stage 2, applied research.

Relevancy & Technical Approach – Maturity & EM Relevance: User Needs

RL-WT021	Cleaning, Decontaminating, and Upgrading Hanford Pits
RL-MW02	Remotely Controlled Size and Volume Reduction Techniques for RH MLLW and RH Transuranic Waste (TRUW)
OH-WV-910	Remote Size Reduction of Components
OH-WV-918	Remote Handling in Extraction Cells
RL-DD08	Remote Cutting Technologies for Buildings 324 and 327
OH-WV-903	Vitrification Expended Material Processing (SVDP-3-99)
SR01-2040	Demonstrate Remote Decommissioning and Disassembly of High Level Waste Processing Equipment

Relevancy & Technical Approach – Maturity & EM Relevance

- Relationship to S&T Thrusts
  - S&T Thrust 1, Closure Site Support
    - Technically relevant, but…
    - Time horizon may be too short.
    - Assuming successful Phase I results, it will likely be a total of at least 5 years to commercialization.
  - S&T Thrust 2, Alternatives to high risk/cost baselines
    - Directly relevant.
    - Will reduce costs and operational risks of remote handling systems that would be implemented with electro hydraulics.

Benefits

- Relative to Competing Baselines
  - Avoidance or reduction of the use of high pressure hydraulic drives in remote, or mechanized equipment.
  - Reduced
    - Initial cost: wiring versus piping; 30-50% reduction.
    - Operating costs: increased reliability with simplified maintenance. LCC estimate: 25-40%.
    - Dependence on limited electro hydraulics technical/crafts skills.

Benefits

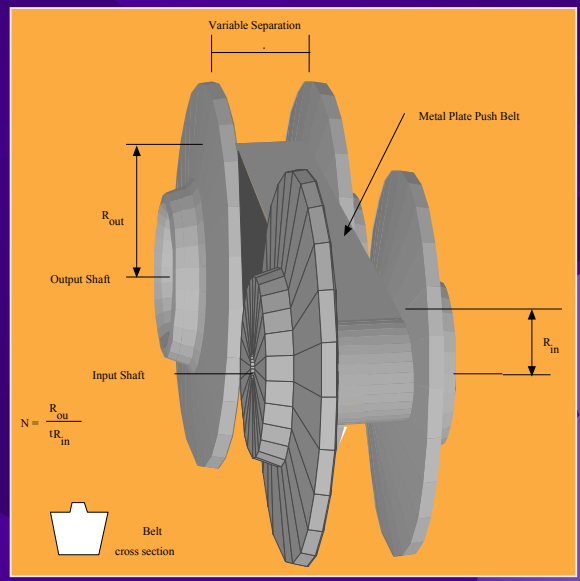
- Benefits to S&T Thrusts
  - S&T Thrust 1 - ???, time horizon too short.
  - S&T Thrust 2 - Yes, lower cost and more reliable alternative to electro hydraulic actuators. Accrued savings could be on the order of millions.
- Potential for Becoming a Baseline

TBA technology is a sub-system technology not normally associated with baselines to remediation. The technology can lead to a change in the baseline design approach of higher payload handling machines.

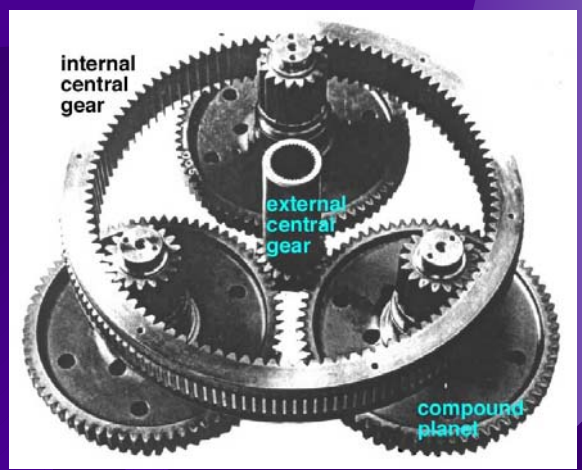
Technical Progress to Date

- Team established.
- Target actuator requirements defined.
- Proof of principle experiment concept and test stand established.
- Completed initial literature reviews of DVT and CVT technologies.
- Completed initial dynamic simulation of a DVT-based TBA.
- DVT design concept 75% complete.
- CVT's being studied further.
- Slow start, but essential on schedule.

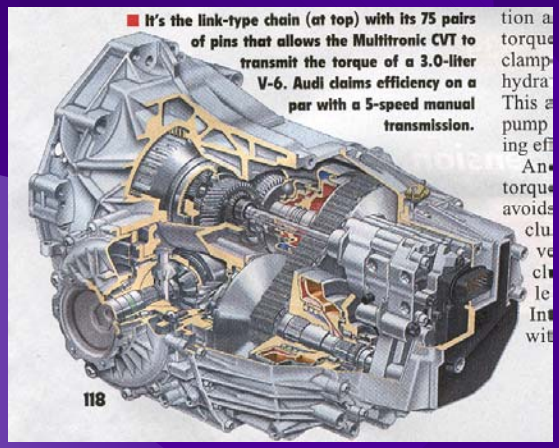
CVT

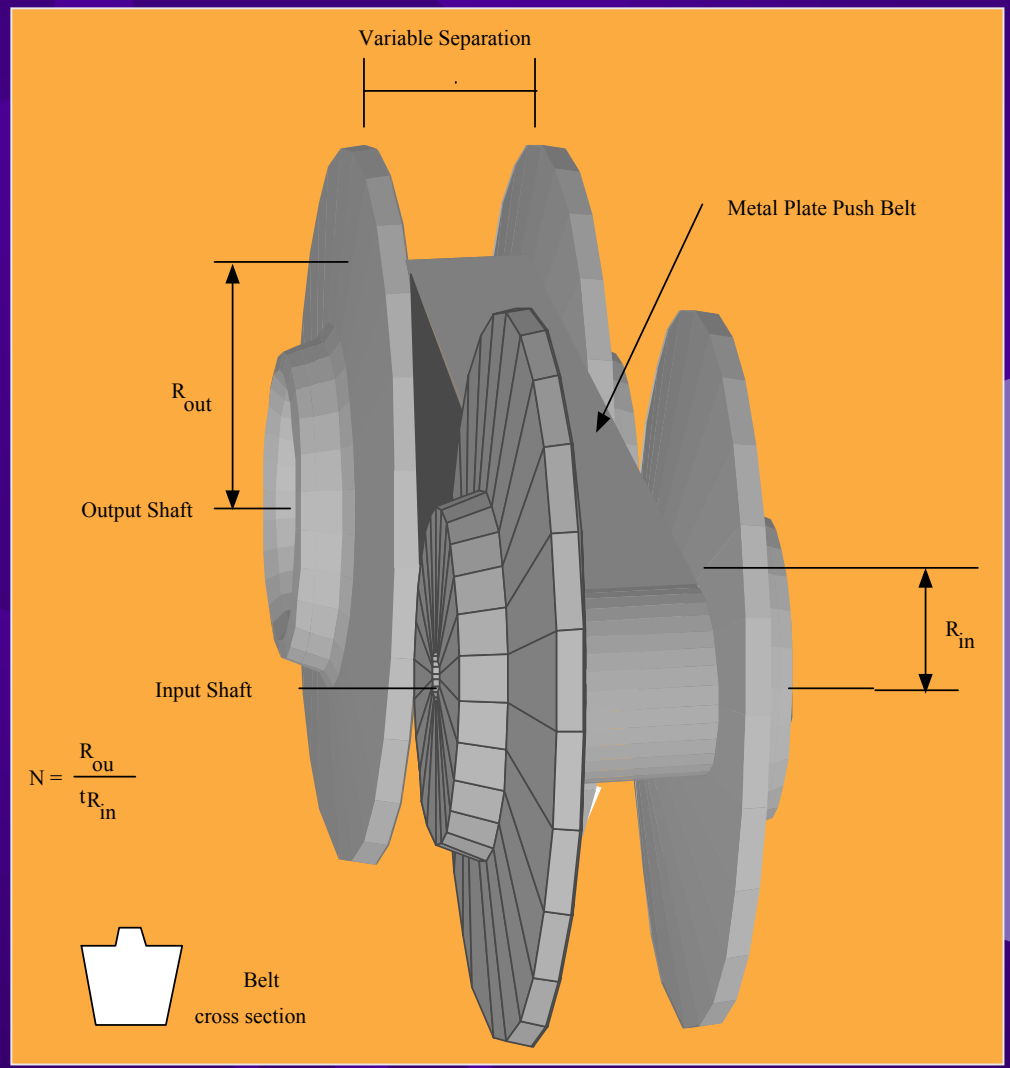


DVT

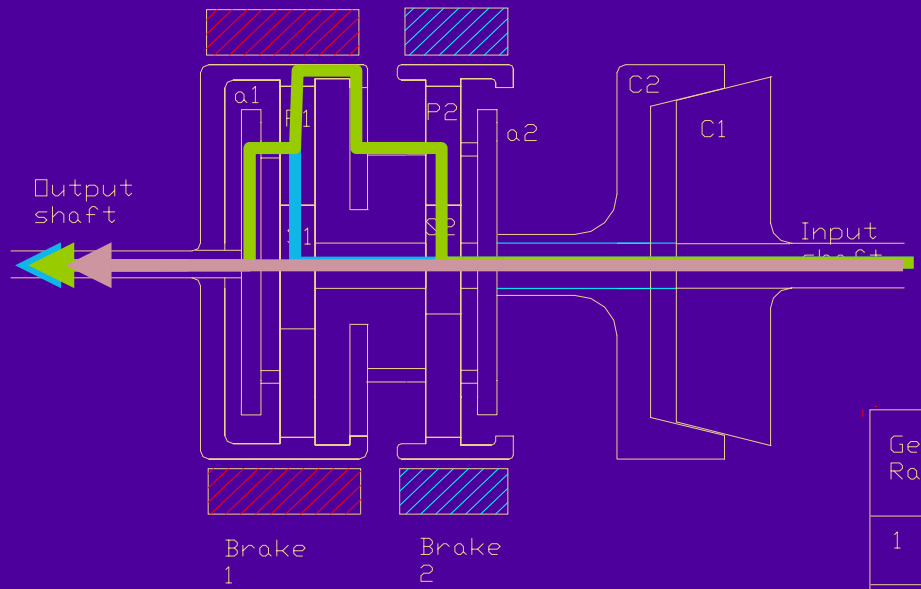


Transmission Basics: CVT's





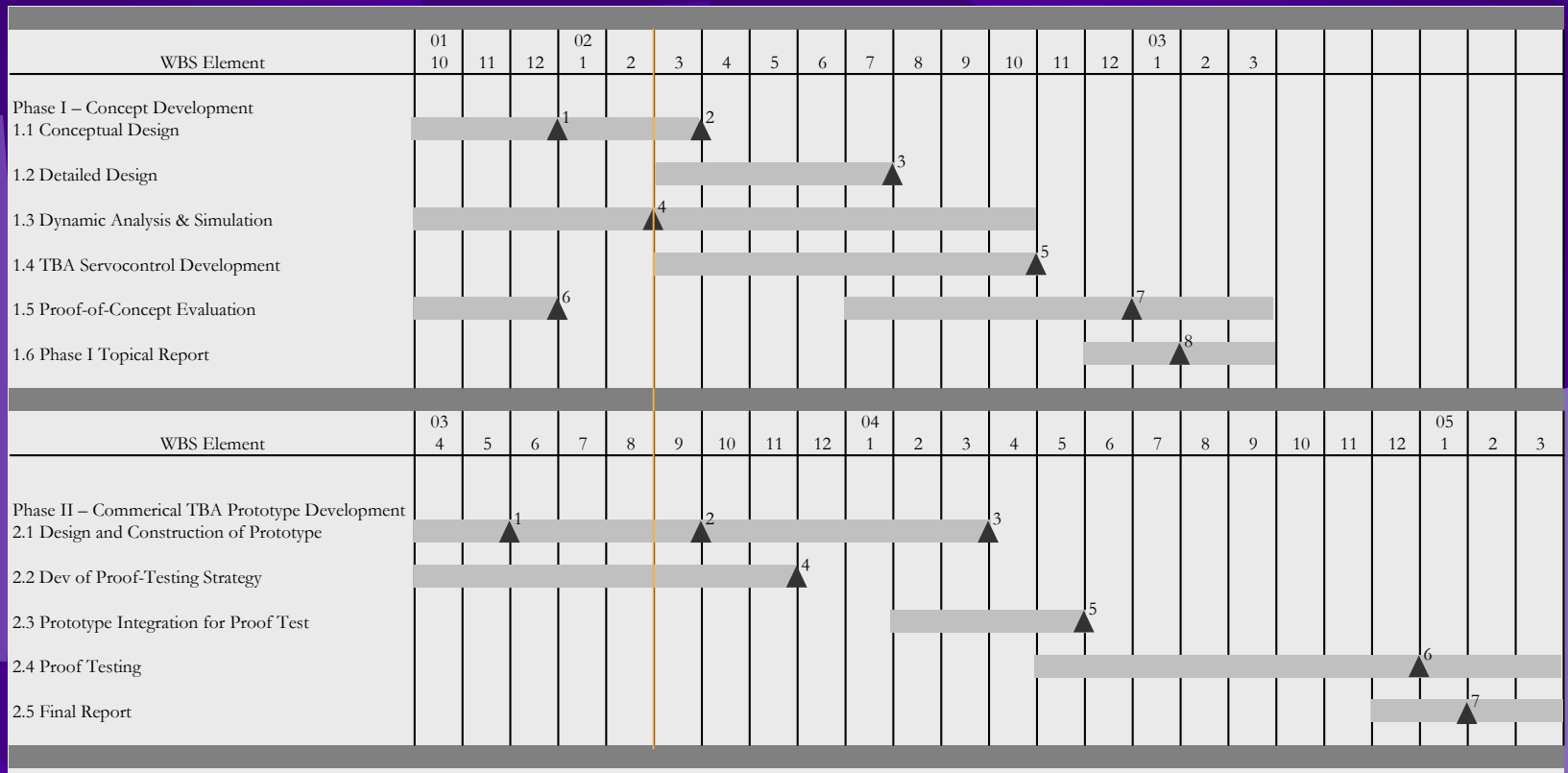
XM Basics: DVT Speed Changing



Operating Table

Gear Ratio	Brake 1	Brake 2	Clutch Position	Power flow indicated by:
1				
2				
3				

Cost & Schedule Status



Milestone Key:
Phase I – Concept Development
1. Requirements Complete
2. Conceptual Design Complete
3. Detailed Design Complete
4. Basic Simulation Operational
5. Servocontrol Design Complete
6. ORNL-donated Test Stand Installed
7. Initial Proof Tests Complete
8. Draft Topical Report Submitted

Milestone Key:
Phase II – Commercial TBA Prototype
1. Requirements Complete
2. Design Complete
3. Fabrication/Procurement Complete
4. Strategy Finalized
5. Integration for Site Tests Complete
6. Initial Proof Testing Complete
7. Draft Final Report Submitted

On Schedule & Within Budget

Miscellaneous

- Stakeholder activities: n/a
- Commercialization: Phase II
- User Interactions: Coordinated with Dennis Haley, DDFA Robotics
- Technical Peer Review: Entrance to Phase II possibly.
- Disclosures/IPR: Patents possible.

Summary

- TBA Applied Research
  - All-electrical alternative to electro hydraulics
  - Potential wide range cost/risk impact in remote and mechanized operations – reduced costs and increased reliability/maintainability
  - Challenges: control & miniaturization
- Relevant to S&T Thrust 2 & existing needs
- Phase I Feasibility verification is within budget and on schedule
- Initial concepts designs – very positive
- Concept feasibility results in March 03